Occurrence of persistent organic compounds in the surface water from the lower stretch of the River Ganga in India

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Introduction

With the growing population in India, there is a steady increase in the exploitation of freshwater resources. In India, depletion of the freshwater quality is mainly due to rapid urbanization and industrialization and lack of systematic management of the generated waste from both domestic and industrial corridor. River Ganga is a transboundary perennial river and a major source of freshwater for northern and eastern part of India. River Ganga in its lower stretch is known as River Hooghly (RH). RH forms the world's largest delta, Sunderban delta shared by the state of West Bengal in India and Bangladesh. The entire stretch of RH has a long legacy of shoreline municipal development and industrial operations and development of the cities and towns. RH is the sole receiving water body for the treated or untreated wastewater from various point and non-point sources.

Persistent organic compounds (POCs) are of concern owing to their long half-lives in a given media, varying from few years to decades. POCs are typically hydrophobic and lipophilic in nature. The tendency of such compounds to partition into lipid is the primary reason for the persistence of these chemicals in biota thereby leading to bioaccumulation and biomagnification. Exposure to very low level of such POCs e.g., organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs) and phthalate esters (PAEs) can lead to a wide variety of health impacts including carcinogenic and mutagenic effects.

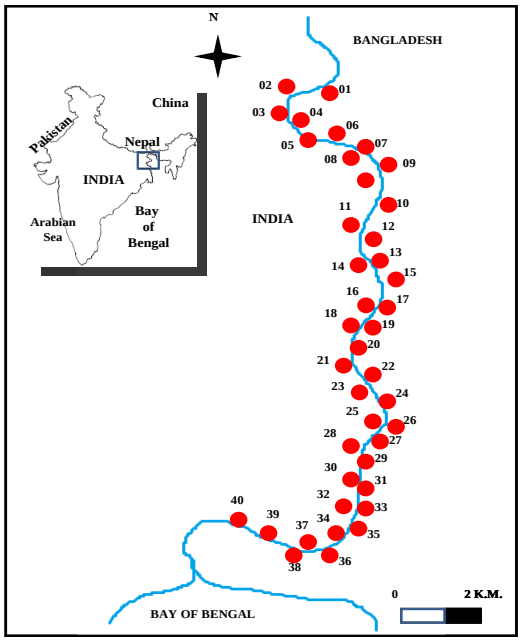

Figure 1. Sampling sites in the lower stretch of Ganges

In the recent past, atmospheric OCPs[1] and PCBs [2] have been observed in and around Kolkata city along the River Hooghly and the authors from one of those studies also reported re-emission of OCPs from soil [3]. Wastewater discharges and surface run-off might act as a primary source for PAEs pollution in the riverine environment. Contamination of these POCs in the river water has become a global problem as it can have severe impact on public health and the inherent ecosystems. Limited data is available on such POCs contamination along the RH. Hence in this study we aim to report the level of contamination of OCPs, PCBs and PAEs in surface water of River Hooghly.

Materials and methods

Sampling

Sampling sites in River Hooghly have been given in Figure 1. For each site, a composite water sample was collected over a length of 500m. Sampling jars were pre-washed with organic solvent before sampling. River water samples were collected in triplicates for backup purposes (in case of breakage of the primary sample) and for laboratory replicates. Following collection, samples were stored in ice box and sent to laboratory and kept at 4ºC until analysis.

Extraction and analysis

Two sets of water samples were extracted by solid phase extraction using 500mg of C18 cartridges (BondElut, Agilent technologies). A known quantity of surrogate standards, viz., 2,4,5,6-tetrachlorom- xylene (TCmX) decachlorobiphenyl and (PCB209) for OCPs and PCBs and Phenanthrene d_{10} for PAEs were added prior to extraction. For OCPs and PCBs, the extract was solvent-exchanged to hexane and concentrated to 1 ml and purified on an 15 mm i.d. aluminum/silica column packed, from the bottom to top, with neutral aluminum (3 cm, 3% deactivated), neutral silica gel (3cm, 3% deactivated), sulfuric acid silica (2cm, 50%) and anhydrous sodium sulphate (1cm). The column was eluted with 20 mL of dichloromethane/hexane (1:1) to yield the OCPs and PCBs. The eluate was further concentrated to 0.2 mL under a gentle nitrogen stream. After PAEs extraction, eluate was passed through anhydrous sodium sulfate column to remove moisture and was concentrated to 1mL. A known quantity of pentachloronitrobenzene (PCNB) was added as an internal standard prior to instrumental analysis. Quantification of POCs were carried out in Agilent-5975 GC-MSD system with a DB 5 MS capillary column (30 m, 0.25 mm, 0.25 mm), operating under selected ion monitoring (SIM) mode.

QA/QC

Chemical standards were purchased from Accustandard Co. U.S. Laboratory. For every set of 7 samples one procedural blank was run. Limits of detection (LODs) were determined as the concentration of each analyte in a sample gave rise to a peak with a signal to noise ratio (S/N) of 3:1.

Result and Discussion

POCs along the lower stretch of Ganges

Boxplot in Figure 2 shows the range of POCs in this study. In general, we observed that the median value for OCPs>PAEs>PCBs. Lack of correlation between the concentration of POCs in surface water of RH and total organic carbon possibly suggests a fresh source.

I. ***PCBs***: Mean concentration of $\sum_{28}$PCBs was 24 ng/L. Heavier congeners were higher compared with lighter congeners. Previously very high PCB concentration was been observed in the Hooghly estuarine sediment [4] and surface water [5]. Distribution of PCB levels are similar along urban and sub-urban transects except for elevated levels of heavier PCBs near Hooghly dock most likely due to port activities [5]. Dioxin like PCBs (DL-PCBs) were found in the range of 0.2 ng/L to 1.9 ng/L. Elevated concentration of DL- PCBs were found in an around the suburban belt of Howrah district, marked by enormous numbers of medium and large scale industries and electronic waste (e-waste) scrap processing workshops.

Electronic waste has been proved to be an important source of PCBs in India [2]. It has been earlier suggested that the abundance of PCB-101, -118, -153, -170 and -180 were due to industrial discharge along the RH [4]. Hence we suspect that the significant levels of heavier PCBs in the suburbs might be associated with the disposal of industrial waste and processed e-waste in the riverine environment. Presence of lighter congeners PCB-44, -52, -101, -118, -138, -149 and 153 could be attributed to the contribution from commercial mixtures, widely used in transformers, electrical equipment [6].

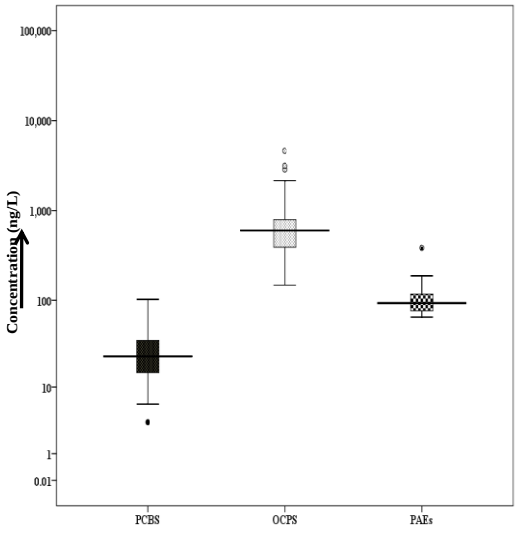

Figure 2. Boxplot showing the range of POCs in log scale

II. ***OCPs:*** Mean concentration of $\sum_{17}$OCPs was 1115 ng/L. Among OCPs, Endrins and Heptachlors were the most predominant and were detected in more than 80 % sites. HCHs were detected in 33 % sites. The dominance of α-HCH indicates usage of technical HCH. Frequent detection may result from atmospheric deposition as elevated atmospheric α-HCH was observed in this region earlier [1]. In addition, soil was found to be acting as secondary source for banned OCPs [3]. β/(α+γ) in more than 80 % sites showed ongoing usage of lindane. Endosulfan and DDT were detected in nearly 25% and 15 % of the sampling sites respectively. Predominance of *p,p'*-DDE suggests past usage of DDT. The concentrations of OCPs in this study were found to be lower than previous study [5] potentially due to the recent ban on the agricultural usage of these compounds.

III. ***PAEs:*** Mean concentration of $\sum_{7}$ PAEs was 105 ng/L. Overall, DEHP and DBP were the main contributor for $\sum_{7}$PAEs along the RH. During 2002, the global production of DEHP and DBP were 394,000 and 134,000 tons respectively [7, 8]. In this study, 90% of $\sum_{7}$PAE came from DEHP (38%), DBP (31%) and DEP (21%). DEHP, DBP and BBP are the predominant congeners of all phthalates in household waste, landfill leachates, and sediment [9]. The high concentrations of PAEs may be related to the intensity of industrial and the surrounding pollution sources in the area and is consistent with other study [8].

Conclusion

The lower stretch of the Ganga River is contaminated with several groups of persistent organic compounds mostly associated with direct discharge of sewage and industrial waste. Samples from the suburban industrial region and port area in the Howrah district contained elevated levels of heavier PCB congeners and pthalates.

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